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Cholewczynski

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(54) **DEBARKER SYSTEMS WITH ADJUSTABLE RINGS**

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B27L 1/08 (2006.01)

(52) **U.S. Cl.**
CPC ***B27L 1/08*** (2013.01)

(58) **Field of Classification Search**
CPC A01G 23/095; A01G 23/097; B27L 1/00; B27L 1/005; B27L 1/08; B27L 1/10
USPC 144/208.1, 208.4, 208.8, 208.9, 208.91
See application file for complete search history.

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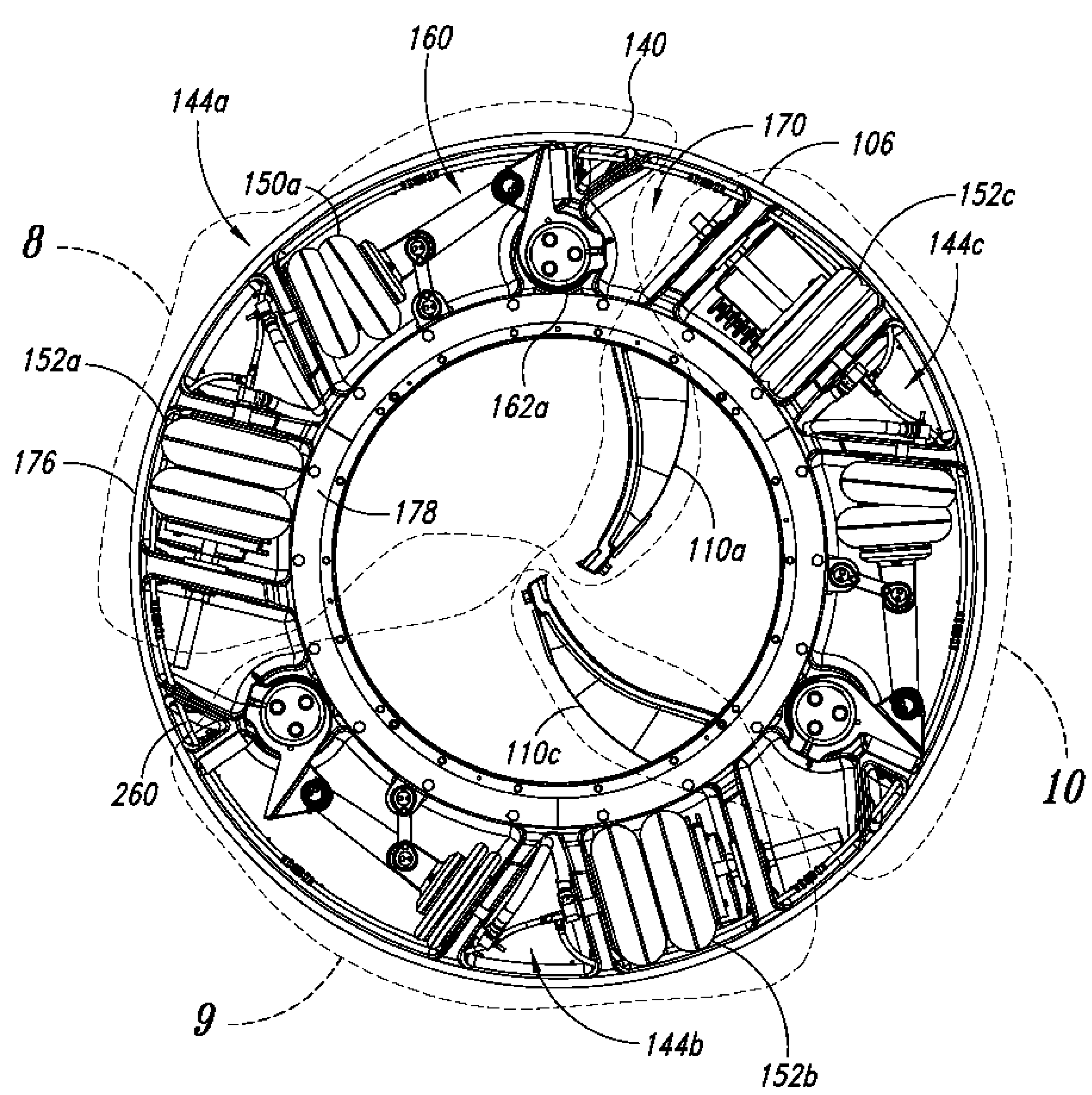
(57) **ABSTRACT**

Apparatuses, systems, and methods for debarking logs are shown and described. The disclosed embodiments can be easily adjusted to process different logs. Air-cell rings provide for a wide range of force gradients to process both large and small diameter logs. The rings include force gradient adjustment mechanisms configurable to provide different force gradients to process logs.

20 Claims, 13 Drawing Sheets



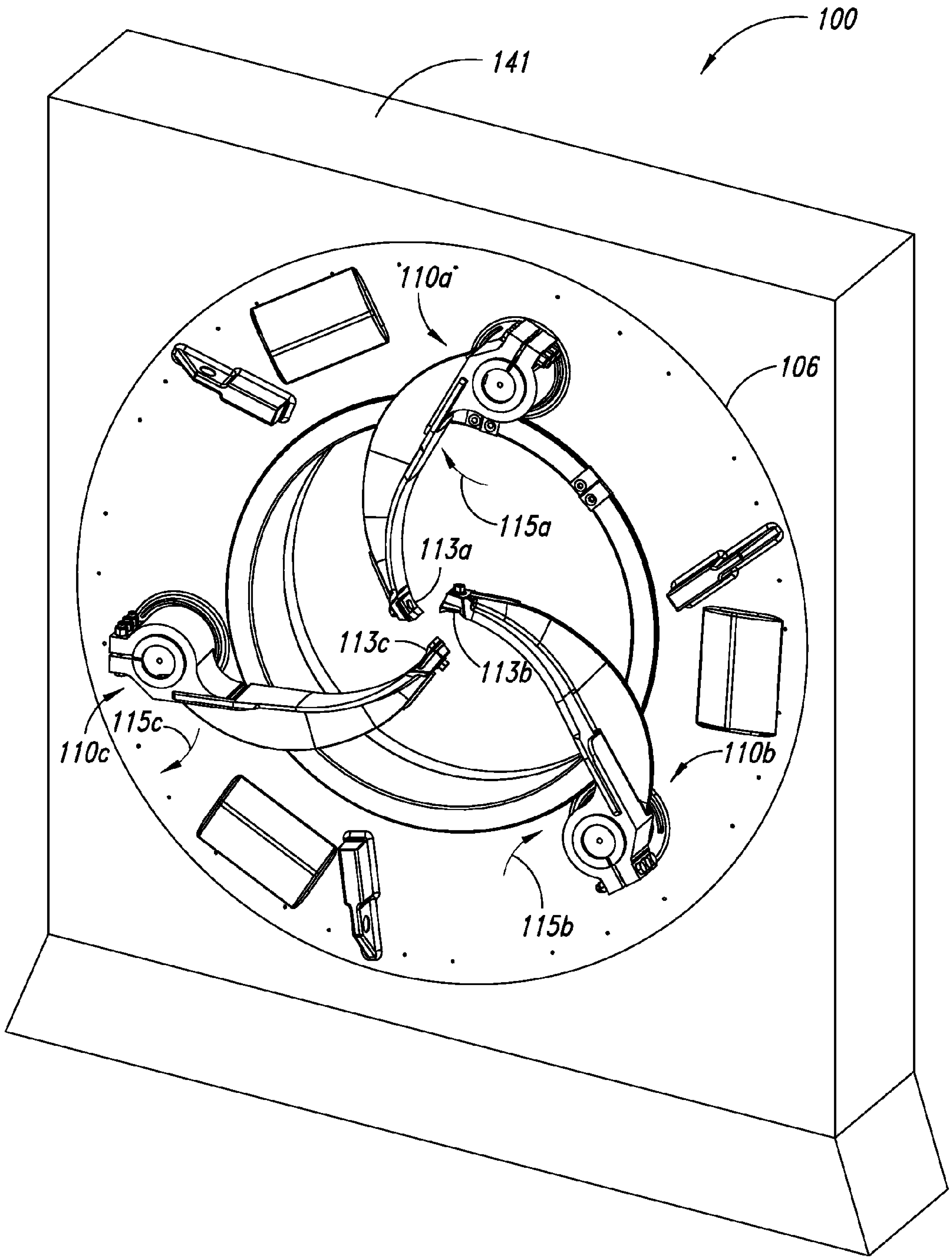


FIG. 1

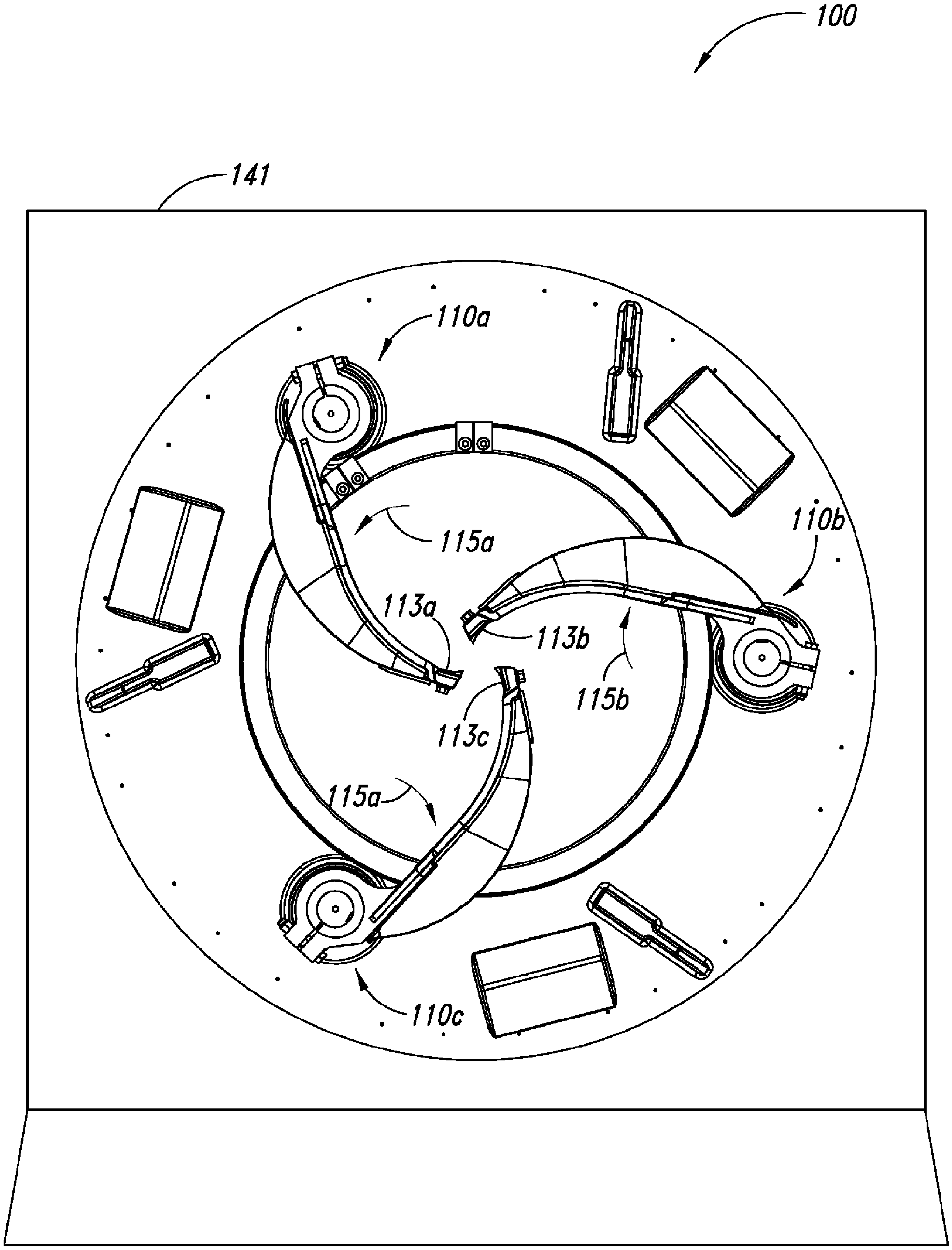


FIG. 2

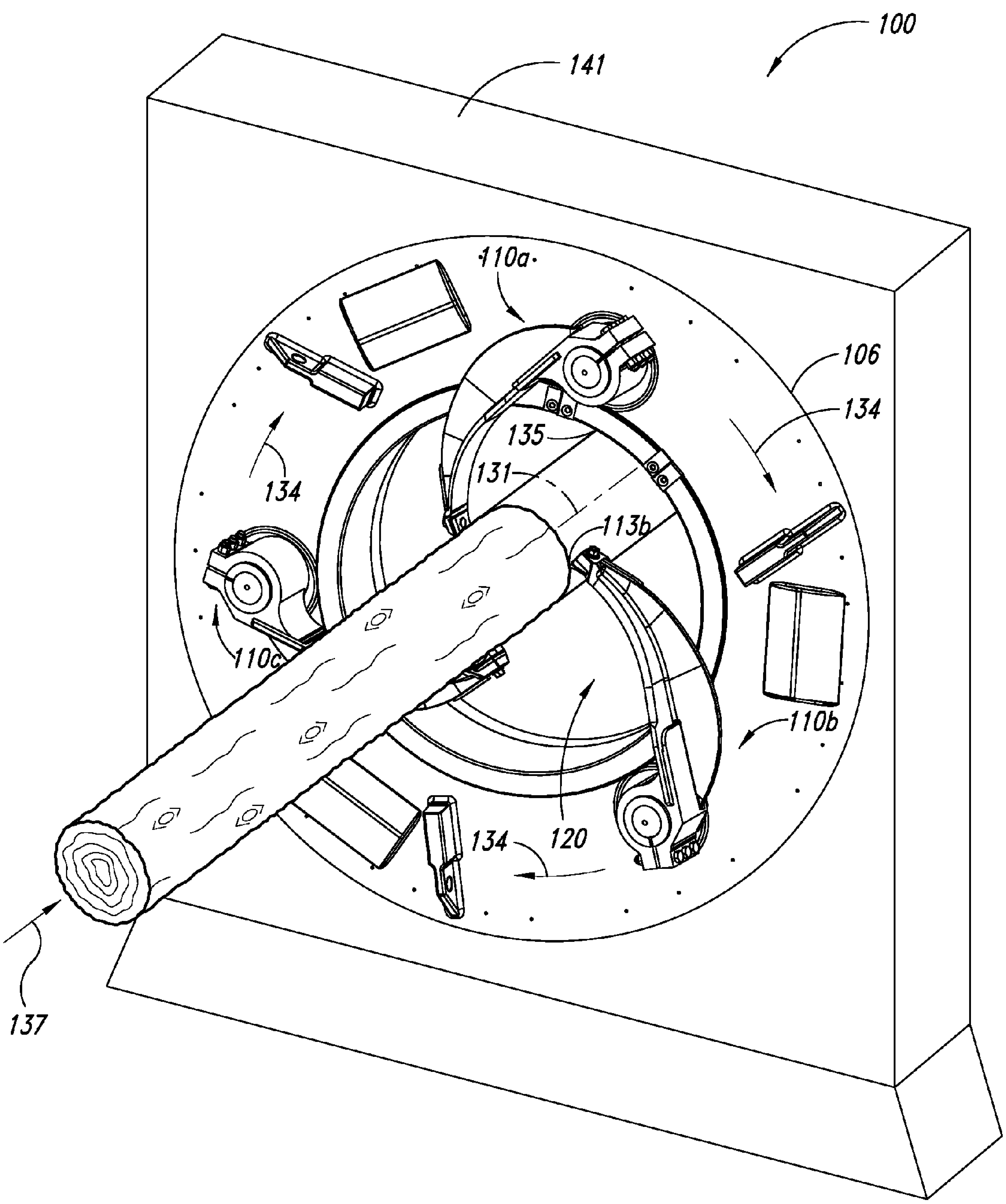


FIG. 3

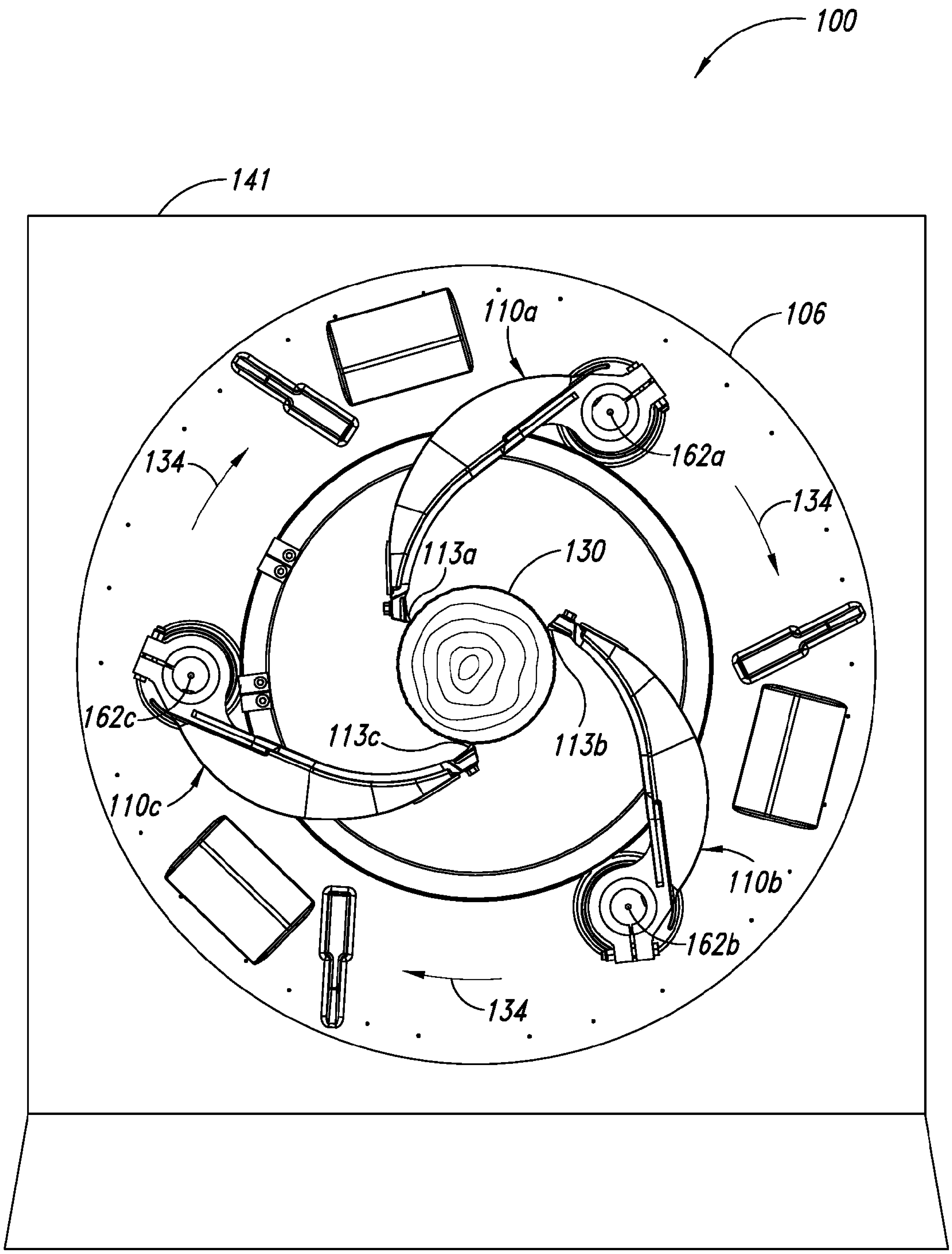

100
141
106
110a
162a
134
134
113a
130
162c
113c
113b
110c
110b
162b
134

FIG. 4

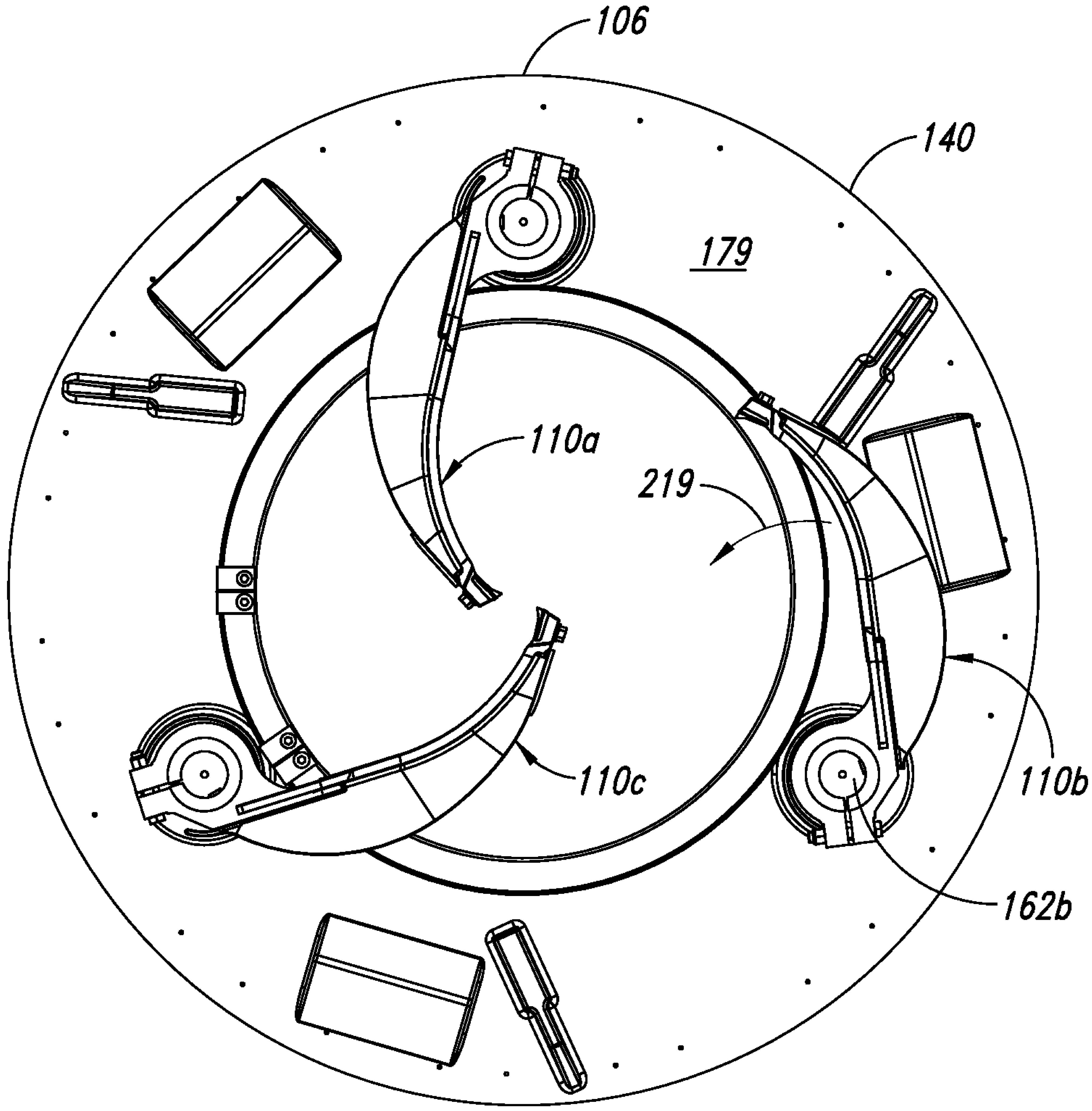


FIG. 5

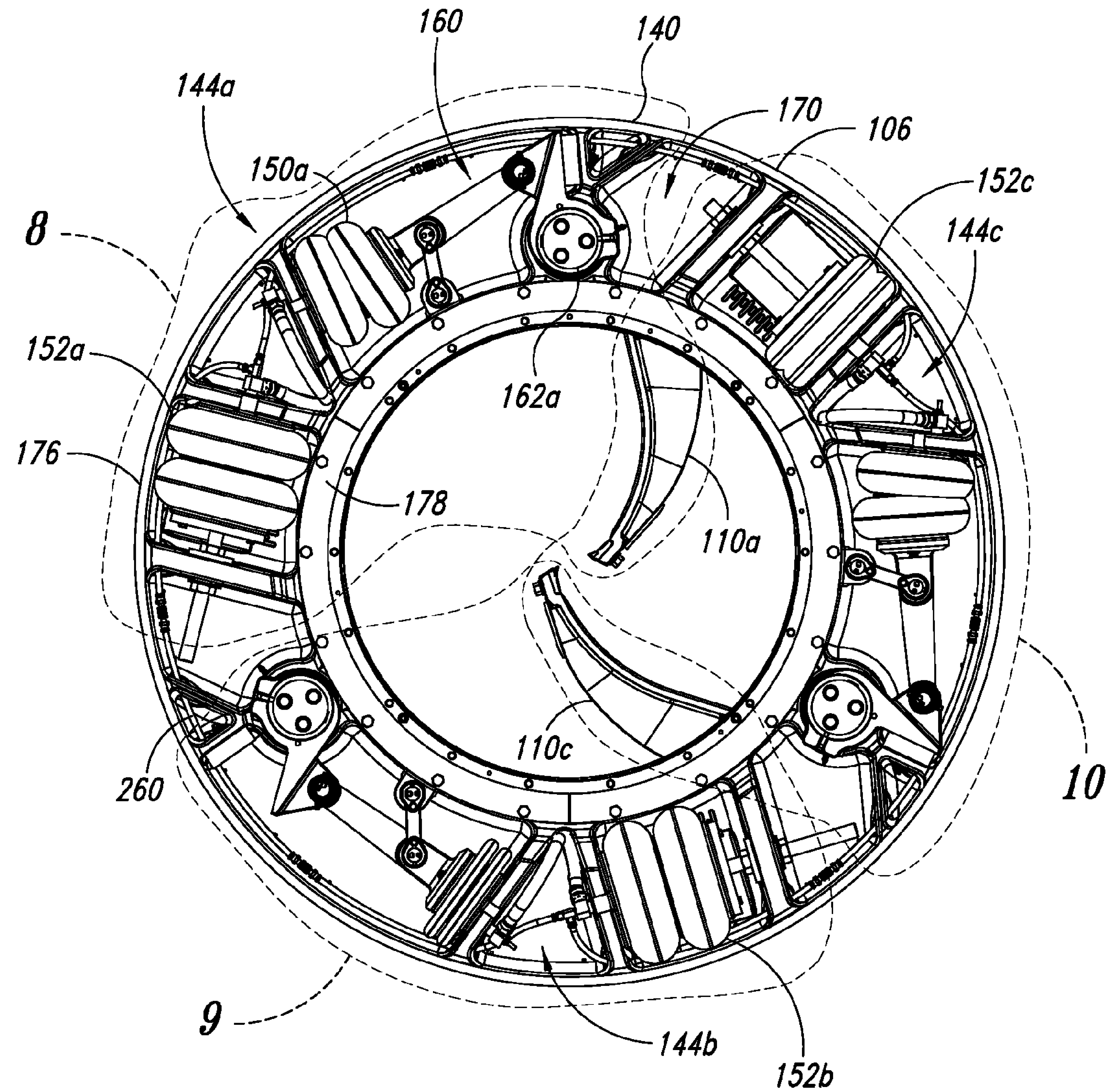

160
140
144a
170
106
150a
152c
8
144c
152a
162a
176
178
110a
110c
260
10
9
144b
152b

FIG. 6

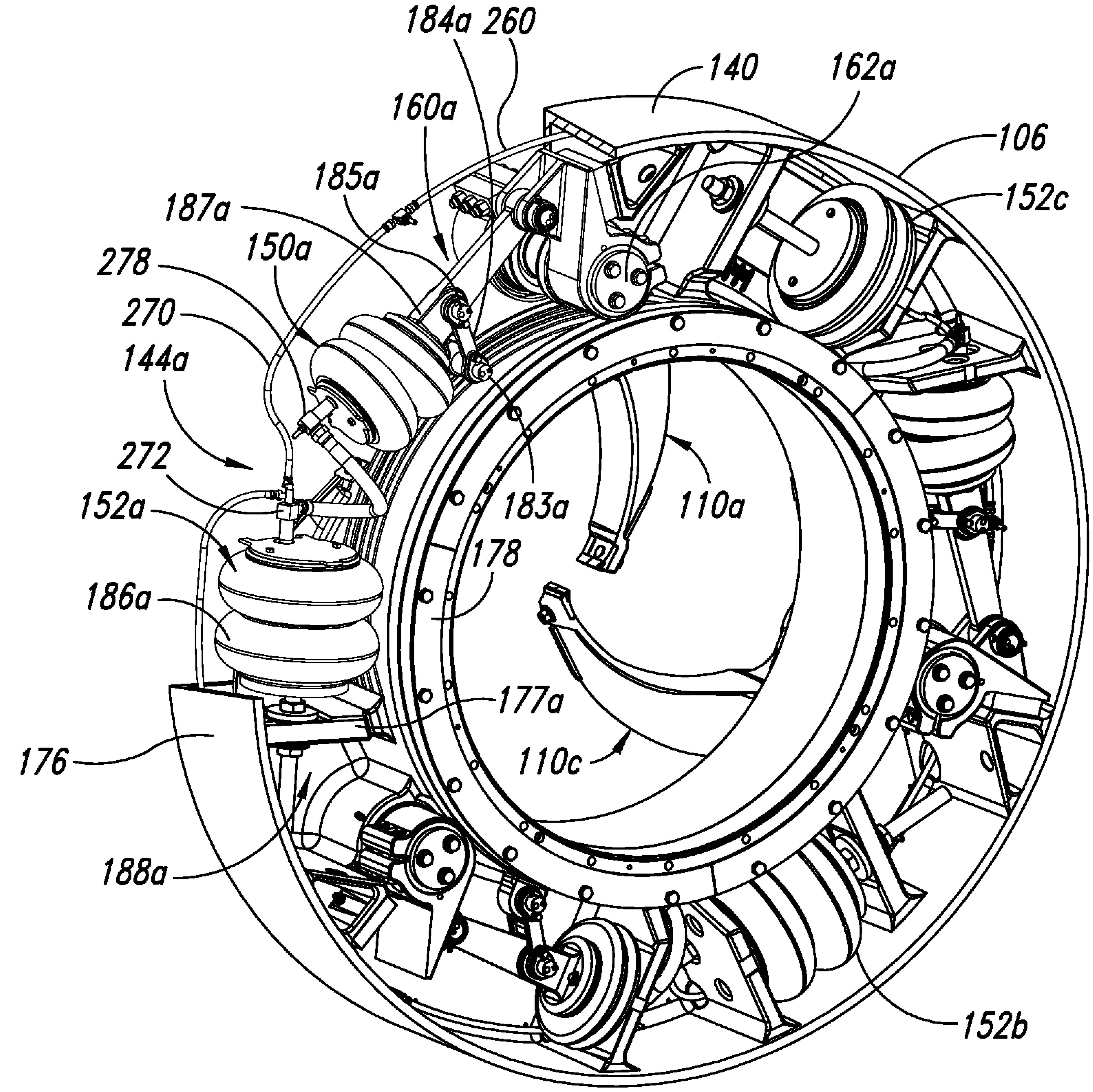

184a
260
140
162a
106
160a
152c
185a
187a
150a
278
270
144a
272
183a
110a
152a
178
186a
177a
176
110c
188a
152b

FIG. 7

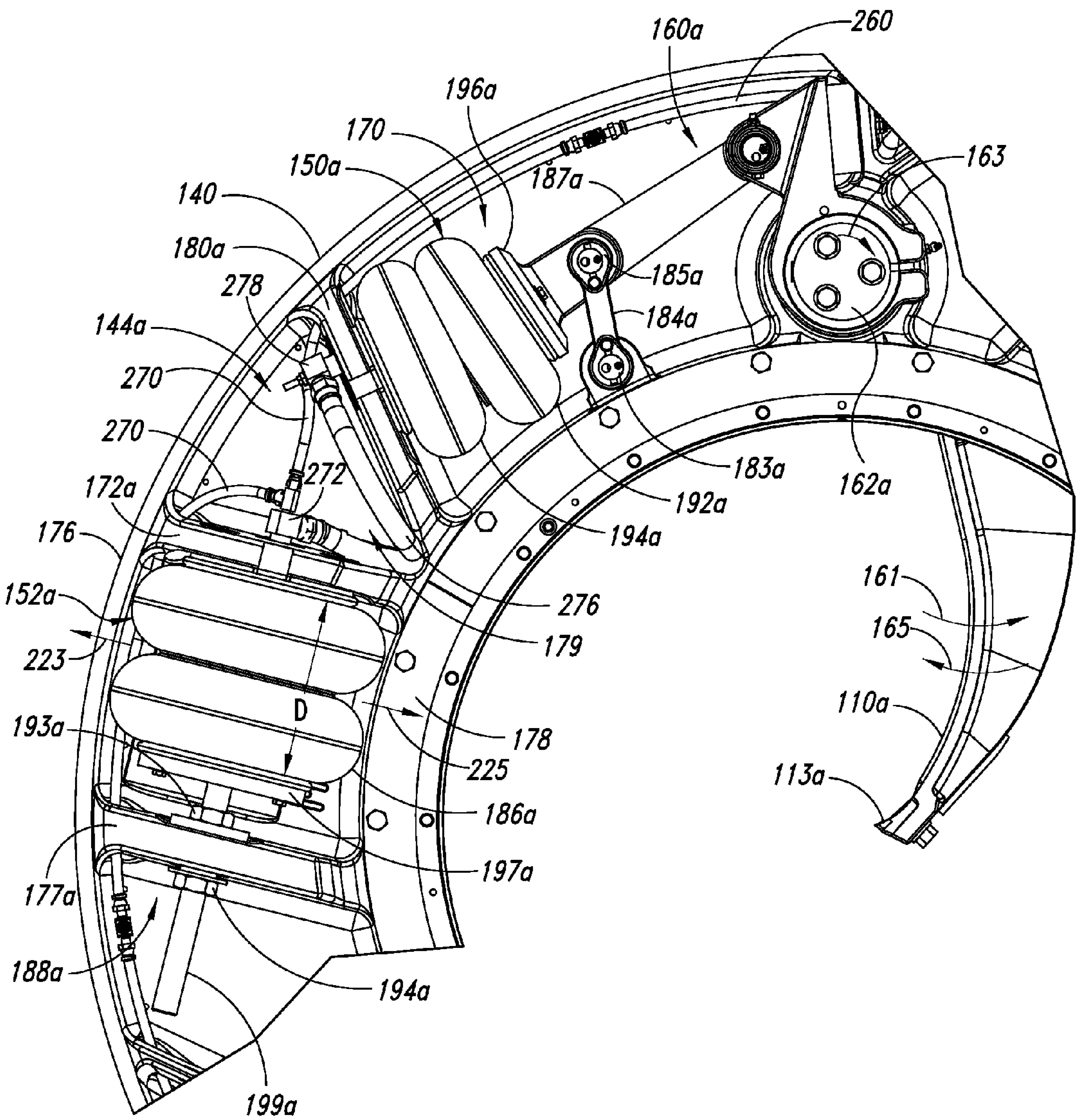

260
160a
196a
170
150a
163
187a
140
180a
185a
184a
278
144a
270
270
183a
162a
192a
172a
272
194a
176
276
152a
179
223
161
165
110a
D
178
225
113a
193a
186a
197a
177a
188a
194a
199a

FIG. 8

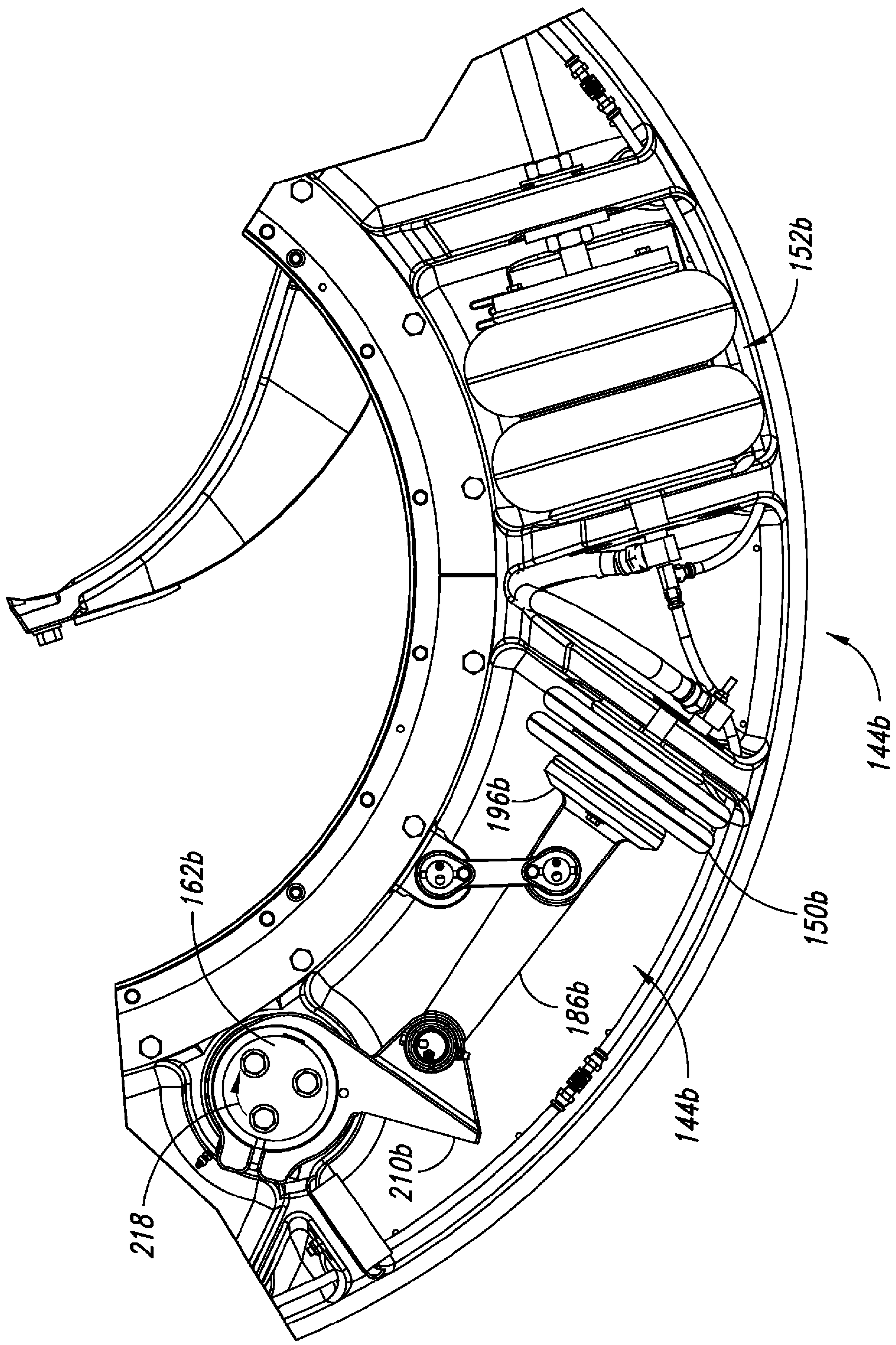


FIG. 9

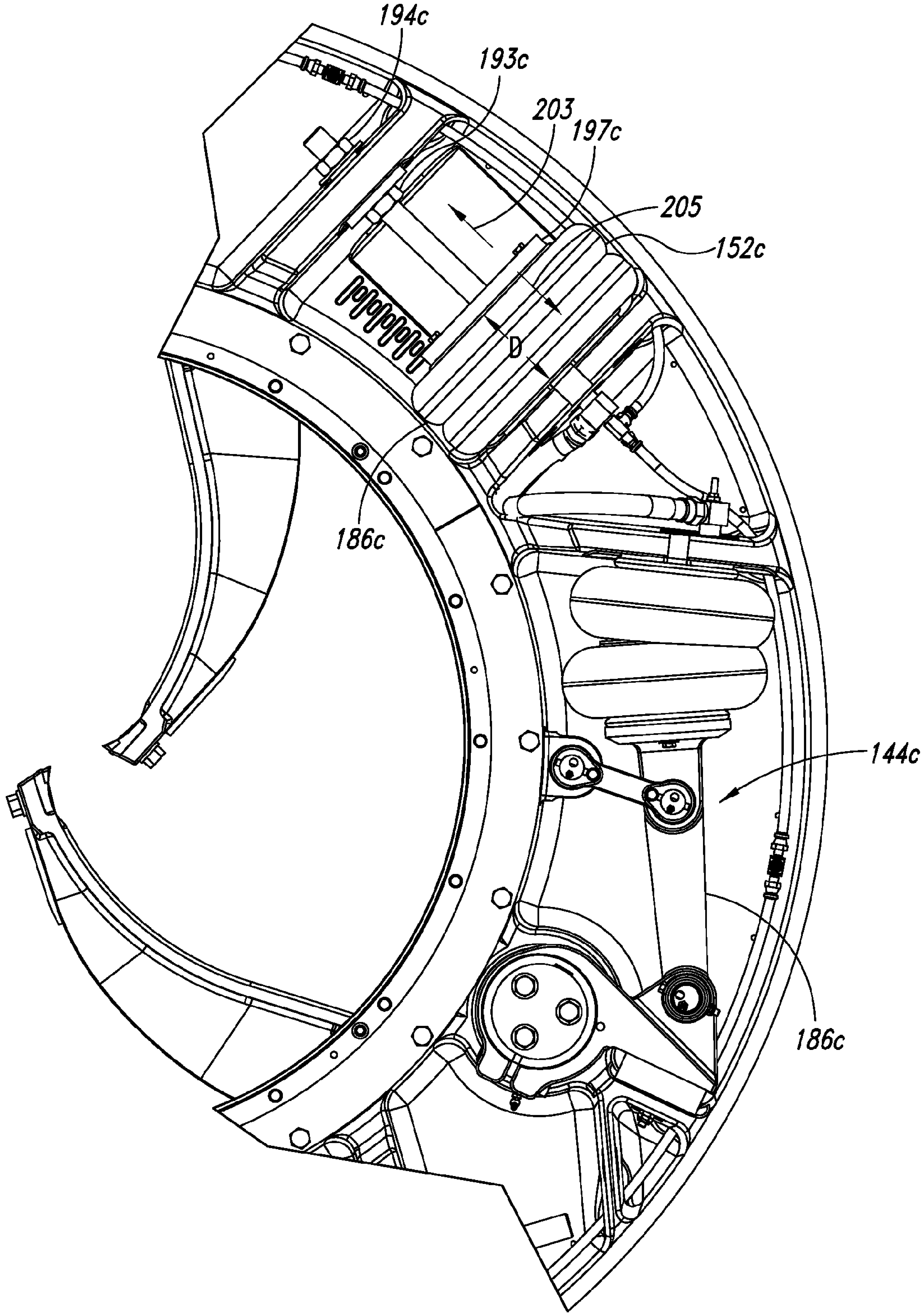


FIG. 10

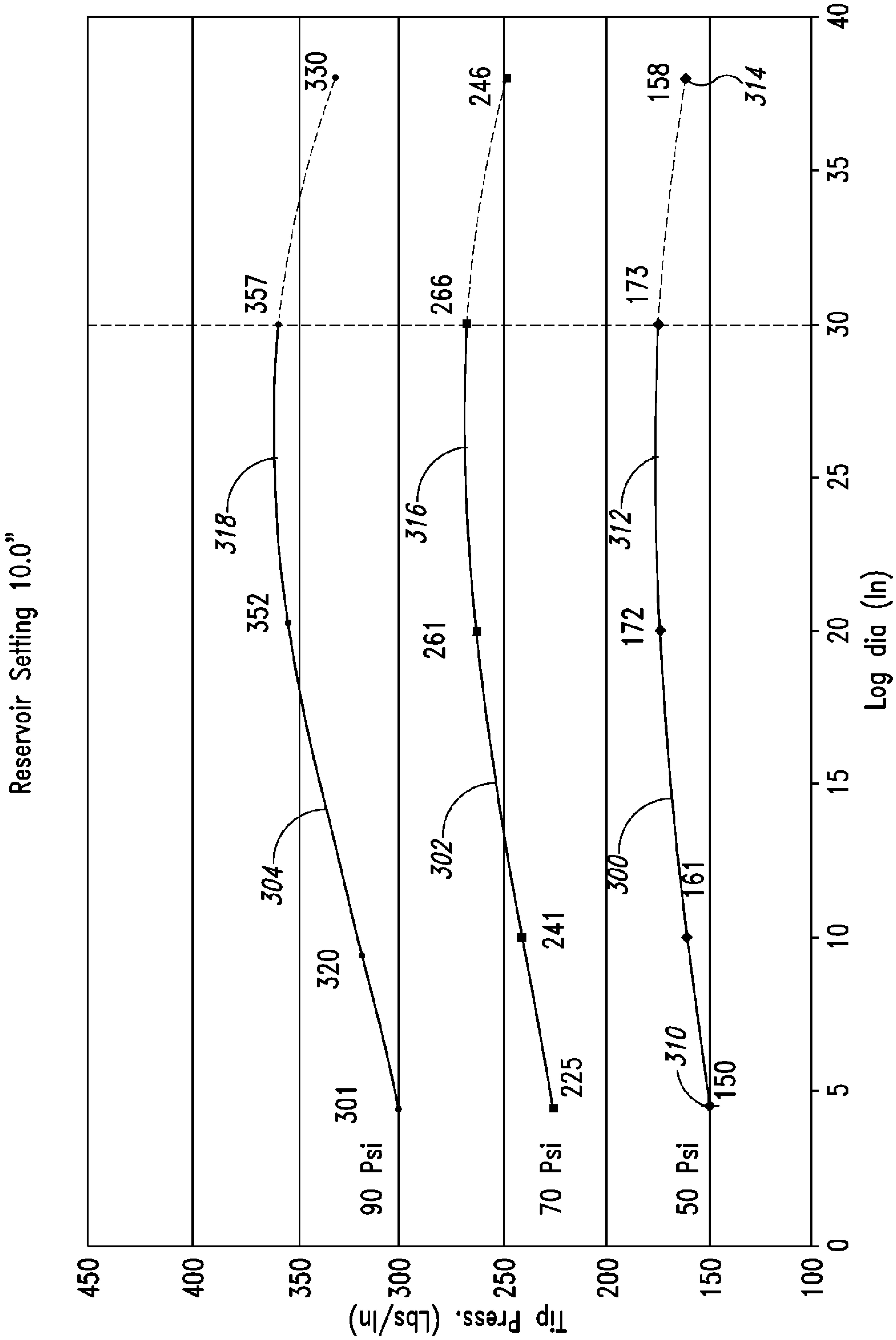

Reservoir Setting 10.0"
Tip Press. (Lbs/In)
Log dia (In)
90 Psi
70 Psi
50 Psi
301
320
352
357
330
225
241
261
266
246
150
161
172
173
158
300
302
304
310
312
314
316
318
450
400
350
300
250
200
150
100
0
5
10
15
20
25
30
35
40

FIG. 11

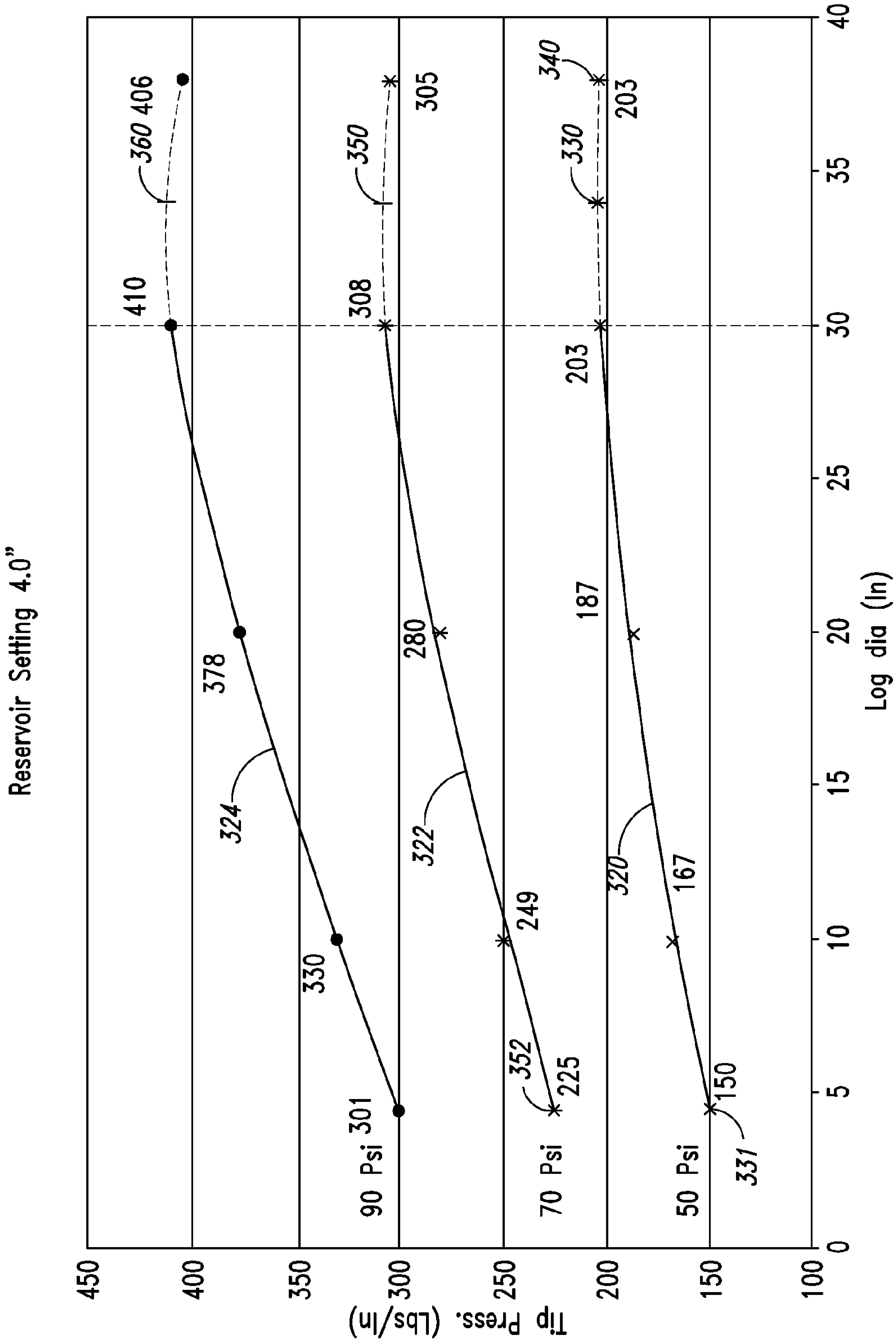

Reservoir Setting 4.0"
Tip Press. (Lbs/In)
Log dia (In)
450
400
350
300
250
200
150
100
0
5
10
15
20
25
30
35
40
90 Psi
70 Psi
50 Psi
301
330
378
410
406
360
324
225
352
249
280
308
305
350
322
150
331
167
187
203
203
330
340
320

FIG. 12

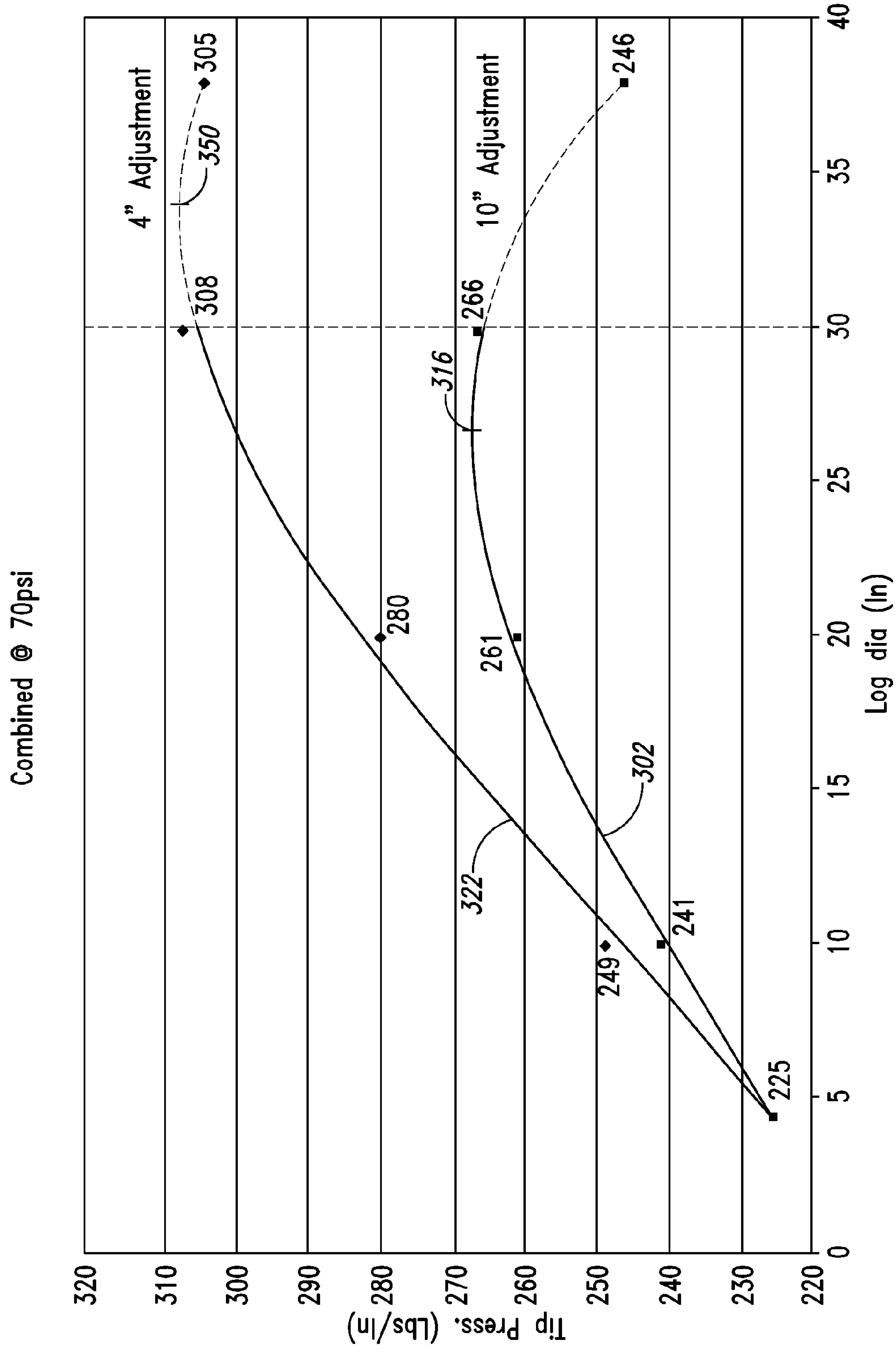

Combined @ 70psi
Tip Press. (Lbs/In)
Log dia (In)
4" Adjustment
10" Adjustment
320
310
300
290
280
270
260
250
240
230
220
0
5
10
15
20
25
30
35
40
305
350
308
280
249
225
246
266
316
261
241
302
322

FIG. 13

DEBARKER SYSTEMS WITH ADJUSTABLE RINGS

BACKGROUND

1. Technical Field

The present disclosure generally relates to debarker systems, and more specifically to mechanical ring debarkers.

2. Description of the Related Art

Rotary log debarkers, commonly referred to as ring debarkers, are used to remove bark to process logs into lumber and other wood products. Rotary log debarkers often have an array of swing arms pivotally mounted to a rotatable ring. Each of the swing arms has a knife. As a log moves towards an opening of the ring, the advancing log contacts and pushes against the swing arms carried by the rotating ring. The log drives the swing arms outwardly until the knives engage the periphery of the log. The knives are urged against the log to scrape off bark.

Rotary log debarkers are typically either air-seal debarkers in which fluid pressure is maintained between the ring and an external fluid source during debarking or air-cell debarkers which are fluidically isolated from an external fluid source during debarking. Air-seal debarkers often have external fluid sources in the form of air compressors capable of delivering pressurized air to air actuators carried in a ring. The air actuators are connected to the swing arms processing the logs. The force exerted by the knives on logs can be changed on the fly by adjusting the air pressure in the actuators. For the air seal ring to operate properly, fluid communication has to be maintained between the external air compressor and the actuators. Components at the interface of the rotating and stationary parts of the ring are susceptible to failure where there is a lack of proper lubrication. Such a failure can be expensive and can result in significant machine down time. For example, significant amounts of frictional heat can be generated between seal components sliding along one another. This heat can lead to seal damage (e.g., degradation at the interface of seal components), unwanted leaking of air, and ultimately failure of seal components.

Air-cell debarkers often have rotatable rings with lightweight air bags for actuating swing arms. Air-cell rings have no air seal components so they can be rotated at relatively high rotational speeds. Each air bag is connected to a lever arm installed on a pivoting shaft carrying a swing arm. When a log enters the debarker, an end of the log strikes and moves the swing arms outwardly. The bags are compressed as the swing arms rotate. The compressed air bags exert a force to actuate the swing arms inwardly even though the air bags are not in fluid communication with an external fluid source. Air-cell rings often provide nonlinear debarking forces versus displacement, thereby providing a force gradient suitable for removing different amounts of bark from logs of different sizes, since bark thickness is often related to log diameters. Unfortunately, conventional air-cell rings are not adjustable so as to provide different force gradients. Thus, air-cell debarkers often properly debark logs having a particular diameter but improperly debark logs of other sizes because a single force gradient may not be suitable to process logs with significantly different diameters.

BRIEF SUMMARY

At least some disclosed embodiments are directed to debarker systems that can be conveniently adjusted to provide different debarking force gradients to process logs, including both large and small diameter logs. A debarker system can

include an air-cell ring with swing arm assemblies actuated by force gradient adjustment mechanisms configurable to provide the different force gradients.

At least some embodiments are directed to a debarker capable of providing different force gradients for debarking logs of different sizes. Inflatable actuation devices are configured to actuate swing arm assemblies and are fluidically coupled to corresponding adjustable volume reservoir devices within a ring. The actuation devices and adjustable volume reservoir devices can be selectively isolated from an external source of pressurized fluid used to periodically pressurize the activation devices. The force, which is applied by the swing arm assemblies to different diameters of logs, is controlled by adjusting the volumes of the reservoir devices.

The debarker, in some embodiments, can be adjusted to minimize, limit, or substantially eliminate under-debarking (e.g., unwanted bark left on the logs), over-debarking (e.g., an excessive usable fiber removed with the bark), inconsistent debarking (e.g., varying applied pressures for logs having the same diameter), or the like. An initial pressure in the inflatable actuation devices can be set using an external fluid source. Small diameter logs can be processed. The pressure in the actuation devices can be adjusted (e.g., using the fluid source) until the small diameter logs are properly debarked. Larger diameter logs can be debarked. If the larger logs are under-debarked or over-debarked, pressure in the actuation devices can be decreased or increased using the adjustable volume reservoir devices. This adjusts the pressure applied by the swing arm assemblies to the large logs and allows fine tuning. Any size log between the small and large logs can be processed with a force that is generally proportional to the established force gradient, thus ensuring proper debarking. This process can be repeated to process different species of logs.

In some embodiments, a debarking apparatus includes a swing arm assembly and an air-cell ring carrying the swing arm assembly. The air-cell ring defines an opening for receiving a log and includes a force gradient adjustment mechanism coupled to the swing arm assembly. The force gradient adjustment mechanism includes a biasing device configured to be compressed as the swing arm assembly moves away from a closed position towards an open position. A force setting reservoir device is fluidically coupled to the biasing device. The force setting reservoir device is reconfigurable to change a debarking force gradient. The debarking force gradient corresponds to forces applied by a debarking tool to logs having different diameters while the biasing device and the force setting reservoir device cooperate to urge the debarking tool against the logs.

In yet further embodiments, a debarking apparatus includes a swing arm assembly having a debarking tool. A ring carries the swing arm assembly. The ring has one or more means for adjusting a force gradient of the forces applied by the swing arm assemblies to logs. The means for adjusting force gradients can include at least one biasing device and at least one force setting reservoir device. The force setting reservoir device can be an air bag, air cylinder, or the like.

A debarking apparatus, in some embodiments, comprises a swing arm assembly including a debarking tool and a ring to which the swing arm assembly is rotatably coupled. The ring includes a force gradient adjustment mechanism configured to alter forces applied by the debarking tool to logs having different diameters. In certain embodiments, the force gradient adjustment mechanism is reconfigurable to provide different force gradients. The difference between the first force gradient and the second force gradient can be at least about 10%, 20%, or 30% for different log dimensions (e.g., diameter). This allows processing flexibility. In certain embodiments, a debarking force gradient can be equal to or greater than about 38% or equal to or smaller than about 10%. The force gradient can be based on the debarking force for debarking a small diameter log and a maximum force being exerted on logs.

Some methods include pressurizing actuation mechanisms in a debarker ring. The actuation mechanisms operate swing arm assemblies to debark logs (e.g., small logs with diameters of about 5 inches). The pressure in the actuation mechanisms can be increased or decreased until desired processing is achieved. Larger diameter logs are then debarked. Reservoir devices are used to adjust a force gradient provided by the swing arm assemblies to achieve the desired processing of the larger logs. Intermediate sized logs are processed using the resulting force gradient.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is an isometric view of a debarker apparatus.

FIG. **2** is a front elevational view of the debarker apparatus of FIG. **1**.

FIG. **3** is an isometric view of the debarker apparatus of FIG. **1** with swing arm assemblies surrounding a log.

FIG. **4** is a front elevational view of the debarker apparatus of FIG. **1** with swing arm assemblies surrounding the log.

FIG. **5** is a front elevational view of a debarker ring having two swing arm assemblies in closed positions and one swing arm assembly in an open position.

FIG. **6** is a back elevational view of the debarker ring of FIG. **5**.

FIG. **7** is a rear, top, and left side isometric view of the debarker ring of FIG. **5** with a portion of a housing shown removed.

FIG. **8** is a detailed view of a force gradient adjustment mechanism of FIG. **6**.

FIG. **9** is a detailed view of another force gradient adjustment mechanism of FIG. **6**.

FIG. **10** is a detailed view of yet another force gradient adjustment mechanism of FIG. **6**.

FIG. **11** is a plot of log diameters versus pressures applied by debarking tools, in accordance with one embodiment.

FIG. **12** is a plot of log diameters versus pressures applied by debarking tools, in accordance with another embodiment.

FIG. **13** is a plot of log diameters versus pressures applied by debarking tools for different settings.

DETAILED DESCRIPTION

The present detailed description is generally directed towards adjustable debarkers. Many specific details of certain exemplary embodiments are set forth in the following description to provide a thorough understanding of such embodiments. One skilled in the art, however, will understand that the disclosed embodiments may be practiced without one or more of the details described in the following description. The debarker components, such as rings and actuation mechanisms, are disclosed in the context of air-cell debarkers because they have particular utility in this context. However, the rings, actuation mechanisms, and other features can be used in other contexts. For example, the actuation mechanisms can be used to move other types of arms or other rotatable components that may or may not process logs, lumber, or the like.

FIGS. **1** and **2** illustrate an air-cell debarker apparatus **100** that includes a rotatable ring **106** and swing arm assemblies **110***a-c* (collectively "**110**"). The swing arm assemblies **110** surround a processing line and include debarking tools **113***a-c* (collectively "**113**"). The swing arm assemblies **110***a-c* can rotate outwardly, as indicated by arrows **115***a-c*, as the ring **106** rotates about a log. The debarking tools **113** are held against a log to process (e.g., scrape, cut, roughen, combinations thereof, or the like) the log's outer surface.

A log can be transported lengthwise along a processing line **131** of FIG. **3**, as indicated by an arrow **137**, towards a ring opening **120**. A drive apparatus in the form of a stationary frame **141** imparts rotary motion to the ring **106** while an end **135** of a log **130** comes into contact with the swing arm assemblies **110**. The swing arm assemblies **110** can slide spirally outward along the end **135** until the debarking tools **113** surround and engage the log's exterior surface. FIGS. **3** and **4** show the debarking tools **113** removing bark while the ring **106** and swing arm assemblies **110** rotate in the clockwise direction (indicated by arrows **134**). The debarking tools **113** can be knives, scrapers, or other types of components suitable for processing logs and can be removably coupled to the ends of main bodies of the swing arm assemblies **110**. Alternatively, debarking tools **113** can be integrally formed with the main bodies of the swing arm assemblies **110**.

FIGS. **5-7** show the air-cell ring **106** including a housing **140** (shown partially cut away in FIG. **7**) and circumferentially spaced apart actuation mechanisms in the form of force gradient adjustment mechanisms **144***a-c* (collectively "**144**"). The adjustment mechanisms **144** can adjust the force gradient of forces applied by the debarking tools **113** to logs. The adjustment mechanisms **144**, as shown in FIG. **6**, are positioned in a housing cavity **170** and located between outer and inner walls **176**, **178**. An annular front plate **179** (see FIG. **5**) extends between the walls **176**, **178**.

Referring to FIGS. **7** and **8**, adjustment mechanism **144***a* includes a biasing device **150***a* and a force setting reservoir device **152***a* fluidically coupled to the biasing device **150***a*. The biasing device **150***a* is coupled to an interior wall **180***a* (shown removed in FIG. **7**). The reservoir device **152***a* includes an inflatable device in the form of an inflatable reservoir **186***a*, illustrated as an inflatable bag, coupled to an interior wall **172***a* and an inflation limiter **188***a* coupled to another interior wall **177***a*. A pivot mechanism **183***a* pivotally couples a link **184***a* to the housing **140**. An arm pivot mechanism **185***a* pivotally couples the link **184***a* to a lever arm **187***a*.

A lever mechanism **160***a* is coupled to a shaft **162***a* carrying the swing arm assembly **110***a*. Rotation of the swing arm assembly **110***a* away from the closed position, as indicated by an arrow **161** of FIG. **8**, causes compression of the biasing device **150***a*. The compressed biasing device **150***a* exerts a restoring force that causes rotation of the shaft **162***a* in the clockwise direction (indicated by an arrow **163** in FIG. **8**) to move the swing arm assembly **110** inwardly (indicated by an arrow **165** in FIG. **8**) towards the closed position.

The adjustment mechanism **144***a* can provide nonlinear restoring forces. The pressure applied by the debarking tool **113***a* to small diameter logs can be less than the pressure applied to large diameter logs. A force gradient can be adjusted to ensure proper processing of logs with significantly different diameters. If larger logs are not processed properly (e.g., too much bark or too little bark is removed), the reservoir device **152***a* can be used to alter the force gradient. By way of example, the reservoir devices **152***a*, **152***b* shown in FIG. **6** are in maximum volume configurations to provide a first force gradient. The reservoir device **152***c* is in an intermediate volume configuration to provide a different force gradient. The force gradients can be the measure of the change of forces (e.g., forces applied by debarking tools to logs) over a specified range, such as a range of log dimensions (e.g., diameters).

The illustrated biasing device **150**a is an inflatable bag with two members **192**a, **194**a in fluid communication with each other. The members **192**a, **194**a can move relative to one another to accommodate displacement and rotation of a lever head **196**a. An inflatable bag can include, without limitation, a flexible bag with one or more chambers, a bellows air bag, or the like, and can be made, in whole or in part, of one or more polymers (e.g., silicon, rubber, or the like), fabric, metal, or combinations thereof, and can provide restoring forces that vary linearly or nonlinearly with displacement. In nonlinear embodiments, the characteristics of the inflatable bag can be selected to achieve desired forces that vary with displacement. Additionally or alternatively, biasing devices can include, without limitation, hydraulic components, energy absorbers, pneumatic springs, air cylinders, or the like. For example, a biasing device can include a combination of different types of inflatable bags or can include an air cylinder.

Referring to FIG. **8**, inflation limiter **188**a is operable to change the holding capacity of the reservoir device **152**a. The inflation limiter **188**a includes a pusher in the form of a plate **197**a connected to the wall **177**a by a rod **199**a. The plate **197**a can be moved by rotating nuts **193**a, **194**a to increase or decrease the holding capacity of the inflatable device **186**a. Other types of mechanical or electromechanical inflation limiters can also be used to reconfigure the device **186**a, if needed or desired.

Throughout the day, a user can move the plate **197**a any number of times. The rod **199**a can have indicia (e.g., lines, markers, or the like) that can be used to accurately position the plate **197**a. For example, a user can move the plate **197**a using indicia on the rod **199**a to locate the plate **197**a at a known position suitable for processing a particular type of log. To process another type of log, the user can move the plate **197**a to another position using the indicia.

Referring again to FIGS. **7** and **8**, a fluid line system **260** fluidically couples the adjustment mechanisms **144** together. A user can use a pump (e.g., a hand pump, a motorized pump, etc.) to deliver pressurized air through the fluid line system **260** to pressurize the adjustment mechanisms **144**a when the ring is stationary. When the swing arm assembly **110**a moves away from the closed position, the biasing device **150**a is compressed. Fluid flows through a valve **278**, a line **276**, and a valve **272**. The fluid proceeds into the reservoir device **152**a and radially expands the inflatable reservoir **186**a (indicated by arrows **223**, **225**), while the inflatable device **186** and biasing device **150**a cooperate to provide a restoring force to dig the debarking tool **113** into the log. Once the log exits the debarking apparatus **100**, the adjustment mechanism **144**a pushes the lever head **196**a to rotate the shaft **162**a. Pressurized fluid flows out of the reservoir device **152**a and into the actuation device **150**a as the swing arm assembly **110**a closes.

FIG. **9** shows the adjustment mechanism **144**b when the swing arm assembly **110**b is in a fully opened position. FIG. **5** shows the swing arm assembly **110**b in the fully open position. The reservoir device **152**a of FIG. **9** contains pressurized fluid that has been pushed out of the collapsed biasing device **150**b. The reservoir device **152**a can be distended and can maintain a desired back pressure, such that the biasing device **150**b presses against the lever head **196**b. As the biasing device **150**b is reinflated, the shaft **162**b rotates (indicated by an arrow **218** in FIG. **9**) to rotate the swing arm assembly **110**b (indicated by an arrow **219** in FIG. **5**).

FIG. **10** shows the plate **197**c holding the inflatable reservoir **186**c in the partially collapsed configuration. A user can rotate nuts **193**c, **194**c to move the plate **197**c, as indicated by arrows **203**, **205**, to expand or collapse the reservoir **186**c.

FIG. **11** is a graph of log diameters versus pressure exerted by debarking tools on the logs. Curves **300**, **302**, **304** have generally similar shapes and correspond to when a distance D (see FIG. **8**) of the reservoir device **152**a is about 10 inches. The curve **300** shows a force gradient corresponding to the adjustment mechanisms **144** containing fluid (e.g., air) at a pressure of about 50 psi. Curves **302**, **304** correspond to the actuation mechanisms at initial pressures of about 70 psi, 90 psi, respectively. The force curves can be shifted upwardly or downwardly by increasing or decreasing the pressure in the adjustment mechanisms. The curvature, slope, and other characteristics of the force curves can be adjusted by altering the settings of the adjustment mechanisms. Details of the force curves **300**, **302**, **304** are discussed in detail below.

At **310**, the debarking tool exerts a pressure of about 150 lb_f/inch on logs having diameters of about 5 inches. For logs having diameters equal to or larger than about 5 inches and equal to or smaller than about 25 inches, the debarking pressure slightly increases with increasing log diameters from **310** to **312**. At **312**, a maximum debarking pressure of about 175 lb_f/inch is applied by the debarking tool. A force gradient of about 17% between **310** and **312** is greater than typical non-adjustable force gradients of about 10% of conventional debarkers. For logs with diameters larger than 25 inches, the debarking pressure gradually decreases with increasing log diameters. At **314**, logs having diameters of about 38 inches are processed using a debarking pressure of about 158 lb_f/inch. The vertical dashed line can correspond to the maximum log diameter to be processed.

A maximum debarking pressure at **316** of curve **302** is applied to logs having a diameter of about 26 inches to about 27 inches. At **316**, the debarking pressure is about 270 lb_f/inch, resulting in a force gradient of about 20%. A maximum debarking pressure at **318** of curve **304** is applied to logs having diameters of about 26 inches to about 28 inches. At **318**, the debarking pressure is about 365 lb_f/inch, resulting in a force gradient of about 21%. The debarker apparatus **100** can be adjusted to provide a desired force curve (e.g., curve **300**, **302**, or **304**) selected based on, for example, the species of logs to be processed, condition of the logs, or other processing criteria.

Curves **320**, **322**, **324** of FIG. **12** correspond to the adjustment mechanisms **144** at working pressures of about 50 psi, 70 psi, and 90 psi, respectively, and the distance D (see FIG. **10**) at about 4 inches. A comparison shows that the curves of FIG. **11** are different from the curves of FIG. **12**. The slopes of curves **300**, **302**, **304** are substantially less than the slopes of the curves **320**, **322**, **324** for smaller diameter logs. Additionally, the maximum debarking pressures of curves **320**, **322**, **324** are substantially larger than the maximum debarking pressures of corresponding curves **300**, **302**, **304**. As shown in FIGS. **11** and **12**, the same tip pressures are applied to 5 inch diameter logs. However, the slope of the curve **320** of FIG. **12** is greater than the slope of the curve **300** of FIG. **11**. Thus, larger diameter logs are processed using a greater pressure when the reservoir device is set at a distance D of 4 inches.

The maximum pressure at **330** of curve **320** corresponds to logs having diameters of about 33 inches to about 35 inches. For logs having diameters equal to or larger than about 5 inches and equal to or smaller than about 33 inches to about 35 inches, the debarking pressure slightly increases with increasing log diameters from **332** to **330**. At **330**, a maximum debarking pressure of about 205 lb_f/inch is applied by the debarking tool. There is a force gradient of about 37% between **331** and **330**. Thus, moving the plate **197** about six inches causes more than 2 times increase in force gradient for the same initial pressurization of 50 psi. For logs with diameters larger than 25 inches, the debarking pressure gradually decreases with increasing log diameters. At **340**, logs having diameters of about 38 inches are processed using a debarking pressure of about 203 lb_f/inch.

A maximum debarking pressure about 310 lb_f/inch at **350** of curve **322** is applied to logs having a diameter of about 33 inches to about 35 inches. At **352**, the debarking pressure is about 225 lb_f/inch, resulting in a force gradient of about 38%. This is almost twice as much as the force gradient of curve **302** of FIG. **11**. A maximum debarking pressure at **360** of curve **324** is applied to logs having diameters of about 33 inches to 34 inches. At **360**, the debarking pressure is about 420 lb_f/inch, resulting in a force gradient of about 40%. As such, the actuation mechanisms can be used adjust the force gradient between about 10% (when the reservoir devices are fully collapsed) and about 40%. Other ranges of force gradients are also possible, if needed or desired.

The holding capacities of the force setting reservoir devices can be selectively increased or decreased to obtain the desired characteristics (e.g., force gradient, maximum tip pressure, minimum tip pressure, or the like). FIG. **13** shows force curves **302**, **322** of FIGS. **11** and **12**, respectively, for reservoir devices at initial pressures of about 70 psi. A curve **302** is generated when the distance D is about 10 inches. The curve **322** is generated when the distance D is about 4 inches. The slope of the curve **322** is generally greater than a slope of the curve **302** for logs with diameters smaller than 20 inches, resulting in significantly higher tip pressures for larger logs. A maximum pressure force at **316** of curve **302** is applied to logs with diameters of about 26 inches to about 28 inches. The maximum force at **382** of the curve **322** corresponds to logs having diameters of about 34 inches to about 36 inches.

To debark logs, a desired initial pressure in the adjustment mechanisms **144** can be set. Logs are then processed. The pressure levels can be adjusted until the desired amount of bark is removed. If different sized logs are under-debarked or over-debarked, pressure in the adjustment mechanisms **144** can be decreased or increased using the reservoir devices **152**. This allows fine tuning of performance. One setup routine includes determining settings to debark small diameter logs (e.g., logs having diameters of about 5 inches to 10 inches). The debarker apparatus **100** is adjusted until the logs are properly debarked. Larger logs (e.g., logs with diameters greater than about 25 inches) are then debarked. The reservoir devices **152** are used to adjust the debarking pressures until the large logs are properly debarked. Thus, the initial pressure and the reservoir devices **150** are used to achieve a desired force gradient. Any size log between the small and large logs are processed with a force that is proportional to the established gradient, thus ensuring proper debarking.

Different types of force setting reservoir devices can be utilized. The reservoir device **152**a discussed in connection with FIGS. **6-8** is illustrated as an airbag. The characteristics (e.g., holding volume, compliance, etc.) of the airbag can be selected to achieve desired force gradients, desired processing consistency desired, service life, or other design criteria. A wide range of force profiles with different gradients, maximum applied forces, or other force profile characteristics can be achieved by selecting appropriate components and ring configuration.

It should be noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise. It should also be noted that the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

Various methods and techniques described above provide a number of ways to carry out the invention. Of course, it is to be understood that not necessarily all objectives or advantages described may be achieved in accordance with any particular embodiment described herein. Thus, for example, those skilled in the art will recognize that the methods may be performed in a manner that achieves or optimizes one advantage or group of advantages as taught herein without necessarily achieving other objectives or advantages as may be taught or suggested herein.

Furthermore, the skilled artisan will recognize the interchangeability of various features from different embodiments disclosed herein. Similarly, the various features and acts discussed above, as well as other known equivalents for each such feature or act, can be mixed and matched by one of ordinary skill in this art to perform methods in accordance with principles described herein. Additionally, the methods which are described and illustrated herein are not limited to the exact sequence of acts described, nor are they necessarily limited to the practice of all of the acts set forth. Other sequences of events or acts, or less than all of the events, or simultaneous occurrence of the events, may be utilized in practicing the embodiments of the invention.

Although the invention has been disclosed in the context of certain embodiments and examples, it will be understood by those skilled in the art that the invention extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses and obvious modifications and equivalents thereof. Accordingly, it is not intended that the invention be limited, except as by the appended claims.

What is claimed is:

1. A debarking apparatus, comprising:

a swing arm assembly including a debarking tool; and

an air-cell ring defining an opening for receiving a log and including a force gradient adjustment mechanism coupled to the swing arm assembly, the force gradient adjustment mechanism including:

an inflatable element configured to be compressed as the swing arm assembly moves away from a closed position towards an open position, and

a reservoir fluidically coupled to and in fluid communication with the inflatable element, the reservoir being reconfigurable to change a debarking force gradient, the debarking force gradient corresponding to forces applied by the debarking tool to logs having different diameters while the inflatable element and the reservoir cooperate to urge the debarking tool against the logs; and

a pusher movable to adjust a volume of the reservoir.

2. The debarking apparatus of claim **1**, wherein the pusher is configured to be moved with respect to the reservoir between different configurations, each configuration corresponding to a respective restoring force gradient provided by the force gradient adjustment mechanism while fluid is capable of flowing between the inflatable element and the reservoir.

3. The debarking apparatus of claim **1**, wherein the pusher is movable with respect to the reservoir from a first position of a plurality of positions to hold the reservoir in a first configuration to a second position of the plurality of positions to hold the reservoir in a second configuration that is different from the first configuration.

4. The debarking apparatus of claim **1**, further comprising a line coupling the reservoir to the inflatable element to allow fluid to flow from the inflatable element to the reservoir as the swing arm assembly moves towards the open position and to allow fluid to flow from the reservoir to the inflatable element as the swing arm assembly moves towards the closed position.

5. The debarking apparatus of claim **1**, wherein the inflatable element is configured to be compressed as the swing arm assembly rotates away from the closed position towards the open position to cause fluid to flow out of the inflatable element and into the reservoir.

6. The debarking apparatus of claim **1**, wherein the inflatable element includes at least one air bag.

7. The debarking apparatus of claim **1**, wherein the swing arm assembly and the force gradient adjustment mechanism cooperate to provide large debarking forces for debarking a log with a diameter of about 20 inches that are greater than small debarking forces for debarking a log having a diameter of about 5 inches, the difference between the large and small debarking forces increases or decreases by altering the configuration of the force gradient adjustment mechanism.

8. The debarking apparatus of claim **1**, wherein the swing arm assembly and the force gradient adjustment mechanism cooperate to debark relatively small diameter logs using a first debarking pressure and to debark relatively large diameter logs using a second debarking pressure, the second debarking pressure is higher than the first debarking pressure.

9. A debarking apparatus, comprising:

a swing arm assembly including a debarking tool; and

a fluidically isolated ring to which the swing arm assembly is rotatably coupled, the ring including a force gradient adjustment mechanism configured to alter a gradient of a debarking force exerted by the swing arm assembly with respect to a displacement of the swing arm assembly, wherein the force gradient adjustment mechanism includes an inflatable element in fluid communication with a reservoir, and a pusher that is movable to adjust a volume of the reservoir to alter the gradient.

10. The debarking apparatus of claim **9**, wherein

the inflatable element is configured to provide the debarking force to urge the debarking tool carried by the swing arm assembly against a log.

11. The debarking apparatus of claim **9**, wherein the pusher is movable with respect to the reservoir from a first position of a plurality of positions to hold the reservoir in a first configuration to a second position of the plurality of positions to hold the reservoir in a second configuration that is different from the first configuration.

12. The debarking apparatus of claim **9**, wherein the inflatable element is configured to be pressed as the swing arm assembly rotates away from a closed position towards an open position to cause fluid to flow out of the inflatable element and into the reservoir.

13. The debarking apparatus of claim **9**, wherein the swing arm assembly and the force gradient adjustment mechanism are configured to cooperate to increase the debarking force for debarking a large diameter log and decrease the debarking force for debarking a small diameter log, the increase or the decrease being selectable by altering a configuration of the force gradient adjustment mechanism.

14. The debarking apparatus of claim **9** wherein the inflatable element includes at least one air bag.

15. The debarking apparatus of claim **9** wherein the pusher includes a plate connected to an interior wall of the fluidically isolated ring by a rod.

16. The debarking apparatus of claim **15** wherein the plate can be moved with respect to the wall by rotating a nut on the rod, to adjust the volume of the reservoir.

17. The debarking apparatus of claim **9**, further comprising another swing arm assembly and another force gradient adjustment mechanism including another inflatable element, another reservoir, and another pusher, the volume of the reservoir being adjustable independently of a volume of the another reservoir.

18. The debarking apparatus of claim **1** wherein the pusher includes a plate connected to an interior wall of the air-cell ring by a rod.

19. The debarking apparatus of claim **1** wherein the plate can be moved with respect to the wall by rotating a nut on the rod, to adjust the volume of the reservoir.

20. The debarking apparatus of claim **1**, further comprising another swing arm assembly and another force gradient adjustment mechanism including another inflatable element, another reservoir, and another pusher, the volume of the reservoir being adjustable independently of a volume of the another reservoir.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,073,233 B2
APPLICATION NO. : 13/149719
DATED : July 7, 2015
INVENTOR(S) : Marek Cholewczynski

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Column 10, Line 33:

"**19.** The debarking apparatus of claim **1** wherein the plate" should read, --**19.** The debarking apparatus of claim **18** wherein the plate--.

Signed and Sealed this
Twenty-ninth Day of March, 2016

Michelle K. Lee
Director of the United States Patent and Trademark Office